Journal of Natural Sciences Research www.iiste.org
ISSN 2224-3186 (Paper) ISSN 2225-0921 (Online)
Vol.8, No.13, 2018

Evaluations and Selection of Improved Common Bean (Phaseulus vulgaris L.) varieties at SNNPR – Ethiopia

AddisuTesfaye Goshime Muluneh Mesele Haile* Alemayehu Zemede
Ethiopian institute of Agricultural Research, P.O.Box 2003, Addis Ababa, Ethiopia

Abstract

On-farm farmer's participatory varietal evaluation and selection methods were applied to select preferred common bean varieties. The study was carried out in Hawassa zuria, Meskan and East Badawacho districts of SNNPR in 2013 cropping season. Objectives were to evaluate beans varieties for yield under farmers' management conditions and to assess farmers' preferences on common beans varieties. Six farmers from three districts with two farmers per district participated in beans trials. Also RCBD with twelve plots per replications was used to evaluate twelve released and pre released common been varieties: SER-125, SER-118, SER-48, SER-78, SER-119, SER-180, SER-176, Dume and at MeskanIbado, Etan, Nassir, Red-kideny used as control. Beans were planted on a 5 m × 4 m plot at a spacing of 40 cm × 10 cm. Data were collected and subjected to analysis using ANOVA table in SAS statistical computer software. Highly significant ($P<0.01$) differences were observed between varieties in seed per pod, 100 seed weight and grain yield. Farmers developed their criterion to assess the performance and acceptability of beans varieties. To select materials both breeders' and farmers' criteria was set to evaluate the materials. The selections and evaluations were done when the crop was close to physiological maturity and also after threshing. Farmers ranked the materials on the basis of the type of material we gave for them. According to farmers' preference at Hawasazuria and BadiwachoDume&SER-119 while at Meskan district Ibado& SER-125 was selected as the first priority variety while at on station SER-125 and SER-119 ranked high and out yielded than other varieties with an average yield of 3.7 and 3.8 t ha^{-1} respectively. The GGE biplot identified SER-78, SER-48 and SER-118 as least desirable common bean varieties. While the GGE biplot analysis revealed three varieties Dume, Nassir and SER-180 were the most desirable across locations. Badawacho and Hawassa on station were identified as best locations for genetic differentiation of genotypes, while location Meskan and Hawassa zuria was the least representative. Introduction of high yielding bean varieties with the desired farmers' traits is expected to restore beans production and contribute to the improved food security in Southern Ethiopia. SER-125 and SER-119 preferred by farmers with their criteria's so important to scale-up seed production and delivery in collaboration with various seed partners.

Keywords: common bean, participatory variety evaluation, selection, adoption

Introduction

Common bean *(Phaseulus vulgaris L.)* is one of the major sources of dietary proteins, vitamins and minerals to millions of resource-poor farmers particularly in developing countries (Broughton et al.2003).It is the most important food legume in Ethiopia (CSA 2012). Nearly 80% of the total dry bean production occurs on high-poverty small holder farms in developing countries (Hayman et al. 2008).Cultivated in a wide range of agro-ecologies and farming systems including well-watered and moisture stressed area as a sole or mixed with other crops (Amede et al 2004).Common bean is perceived by many farmers and development agencies as a food security crop because of its short life cycle in comparison to crop like maize (Rao 2001; Amede et al. 2004). According to CSA data Southern Ethiopia accounts about 21.5% of the country's common bean production and 23.7% of its total area coverage of common bean (CSA 2012).In this part of the country, bean production is carried out mainly by resource-poor small holder farmer whose production conditions are diverse and marginal (Amede et al 2004).

In highly variable and marginal environments, varieties tend not to be formally improved and seed is reproduced in the informal system. In such farming systems crop genetic diversity co-evolves with the social, economic and environmental context (Almekinderset al.1994; McGuire 2007). Many improved varieties with high on-station yield were developed in Ethiopia from local international genepools (Asfaw 2008).However majority of the varieties are not adopted and common bean production continues to depend on range farmer varieties(Asfaw et al.2009) and average regional yield is around 1.1 tonne per hectare (CSA 2012). Moreover on station yield frequently do not represent farmer's field in many marginal agronomic and environmental aspects (Ceccarelli, 1994).

Direct selection for grain yield in the target environment can increase yield significantly, especially when large differences exist for yield between the target environment and the research station representing the target environment (Banziger et al. 1997; Murphy et al., 2007). Breeding strategy that integrates selection criteria farmers and other product-chain actors with the agro ecological adaptation may be a more effective strategy to target the diverse environments and the user needs (Sperling etal.2001;Ceccarelli and Grando 2009).Participatory plant breeding as an alternative approach to breeding to overcome and even exploit the interaction of genotype, environment and socio-cultural or economic factors (GxExS) is now widely advocated (Almekindres and Elings 2001;Ceccarelli and Grando 2007).

Centralized breeding may often be less effective method than participatory variety selection for producing cultivars targeted for marginal environments (Witcombe et al., 1996)

Common beans breeding program in the country has developed many productive varieties that could increase yield per unit area following conventional breeding approach. However, there has been a very limited uptake of improved bean varieties by smallholder farmers' in the south region. This could be due nonparticipation of the farmers and other actors in the variety development process that attributed in lack of acceptable characteristics of the varieties such as seed color, size, cooking time, taste, poor adaptation or inadequate diversity to meet local preferences of bean farmers and consumers. Participating farmers in the breeding process helps to fit the crop to specific needs and uses of fanners' communities (Ceccarelli et al, 2000) and improve cultivar adoption (Home and Stur, 1997). Participation in common bean breeding by exploring different methods to capture farmers' preferences, understand the various source of variation in farmers' preference and asses farmers' effectiveness in identifying among common bean varieties that were develop for high yields in southern region of Ethiopia (Asfaw et al, 2011). The objective of this study were to evaluate beans varieties for yield under farmers' management conditions and to assess farmers' preferences on bean varieties

Materials and Method

Six farmers from three districts with two farmers per district participated on farm beans trials at 2013 cropping season. Seven prerelease and two released red common bean varieties (SER-125, SER-118, SER-48, SER-78, SER-119, SER-180, SER-176, checks Dume, Nassir) were planted on a 5m x 4m plot at a spacing of 40 cm × 10 cm. Besides the on farm trials at on-station a randomized complete block design with three replication and twelve plots per replication was used to evaluate five released and seven pre released common been varieties: SER-125, SER-118, SER-48, SER-78, SER-119, SER-180, SER-176, checks Dume , Nassir, Ibado, Etan, Red-kideny used as control. The genotypes of common bean varieties were obtained from Melkasa Agricultural Research Center. All agronomic parameters were collected and recorded at different growth stage of the plant. Participatory variety evaluation and selection were done at physiological maturity and at harvesting time with 73 male farmers and 16 female farmers in the districts of Meskan, Badawacho and Hawassa zuria. Data was subjected to analysis using ANOVA table in SAS statistical computer software and the genotype effect and genotype environment interaction analyzed by Genstat 13th Edition with GGE biplot software (Yan.,2001).

Result and Discussion

Participatory Variety Selection was carried out for Common bean varieties at all SIMLESA districts. Researchers, experts from bureau of agriculture, development agents from different kebeles and farmers from each districts and neighboring district were participated in the PVS. Nine varieties with two recently released common bean varieties and seven on pipeline materials were tested for their performance both on farm and on-station. To select materials both breeders' criteria and farmers' criteria was set to evaluate the materials. Farmers ranked the materials on the basis of the type of material we gave for them. According to their preference at Hawasa zuria and Badiwacho Dume and SER-119 (Table1&3) while at Meskan district Ibado and SER-125 was selected as the first priority variety (Table 2).

Table 1: Farmers evaluation criteria of nine bean varieties and ranking at Hawassa zuria, 2013 cropping season.

Variety	Criteria								Total	Rank
	Ses	EM	Mark	Yield	Disease	SSRFS	BM	color		
Nassir	4	1	1	4	2	1	4	2	19	8
Dume	4	4	5	4	4	4	3	4	32	1
SER-180	3	3	4	4	4	3	4	4	29	3
SER-119	3	3	5	4	4	3	4	5	31	2
SER-125	3	2	2	3	4	2	3	4	23	4
SER-176	2	2	2	4	4	2	3	3	22	5
SER-118	3	2	2	3	4	2	3	3	22	5
SER-48	3	2	2	3	4	2	3	3	20	7
SER-78	3	5	2	1	1	5	2	2	21	6

Key: Ses = seed size, EM = early maturity, Mark = high market demand, yield = high yielding, disease = disease resistance, , and S = suitability to short rainfall farming system. Scores: 5 = highly preferred, 1 = least preferred.

Table 2: Farmers evaluation criteria of twelve bean varieties and ranking at Meskan, 2013 cropping season.

Variety	Criteria								Total	Rank
	Se	EM	Mark	Yield	Disease	SSRFS	BM	Color		
Nassir	4	2	2	3	1	2	4	2	20	9
Dume	2	3	3	4	4	3	4	3	26	6
SER-180	3	3	3	4	4	3	4	3	27	5
SER-119	3	3	3	4	4	3	5	3	28	4
SER-125	3	3	3	4	5	3	5	4	30	2
SER-176	3	3	3	4	4	3	4	3	27	5
SER-118	3	2	2	3	4	2	4	3	23	7
SER-48	2	2	2	3	4	2	3	2	20	9
SER-78	2	5	2	1	2	5	2	2	19	10
Ibado	5	3	5	3	4	3	4	5	32	1
Etan	2	2	1	3	3	3	2	1	17	11
Red kideny	4	3	4	3	4	3	4	4	29	3

Key: Ses= seed size, EM = early maturity, Mark = high market demand, yield = high yielding, disease = disease resistance, , and S = suitability to short rainfall farming system. Scores: 5 = highly preferred, 1 = least preferred.

Table 3: Farmers evaluation criteria and ranking of nine bean varieties at Badawacho

Variety	Criteria								Total	Rank
	Ses	EM	Mark	Yield	Disease	SSRFS	BM	color		
Nassir	4	1	1	4	2	1	4	2	19	8
Dume	4	4	5	4	4	4	4	4	33	1
SER-180	4	3	3	3	4	3	3	3	26	3
SER-119	4	3	4	4	5	3	4	5	32	2
SER-125	4	3	3	4	4	3	3	4	24	5
SER-176	3	3	3	3	4	3	3	3	25	4
SER-118	3	3	2	3	3	3	3	3	23	6
SER-48	3	3	2	3	3	3	4	3	24	5
SER-78	3	5	2	1	1	5	2	2	21	7

Key: Ses= seed size, EM = early maturity, Mark = high market demand, yield = high yielding, disease = disease resistance, , and S = suitability to short rainfall farming system. Scores: 5 = highly preferred, 1 = least preferred.

In addition to the PVS activities another common been experiment was carried out at Hawassa on-station and it was laid down on completely randomized block design with three replications having a plot size with 4m x 5m and with the spacing 40 cm and 10 cm between rows and plants in a row respectively. Twelve varieties were evaluated under conventional tillage practice. Analysis of variance for grain yield and other agronomic parameters was done using SAS software. Analysis of variance indicated that there was statistically significant difference for grain yield, seeds per pod, 1000 seed weight among the common bean varieties tested. The highest grain yield was harvested from SER-125 (3.8 ton ha^{-1}) and SER-119 (3.7 ton ha^{-1}) while the lowest (2.6 t ha^{-1}) was recorded from SER-78 (2.6 ton ha^{-1}) and SER-118 (2.57 ton ha^{-1}) (table 4).

Table 4. ANOVA table of common bean agronomic parameters for varieties evaluated on station, 2013 cropping season

Varieties	Pod/plant	seed/pod	1000 seed wt	Biomass (t/ha)	Seed yield (t/ha)
SER-78	5.1^{abcd}	19.58^{cd}	224.23^{ef}	4.7^{c}	2.6^{d}
SER-176	5.93^{a}	26.47^{ab}	257.77^{cdef}	7.77^{abc}	3.4^{ab}
Nassir	5.67^{ab}	26.8^{a}	205.23^{f}	7.37^{bc}	3.17^{bc}
SER-119	5.1^{abcd}	17.16^{cd}	276.3^{cde}	11.3^{a}	3.7^{a}
SER-118	5.5^{abc}	19.8^{cd}	239.5^{def}	6.67^{bc}	2.57^{d}
SER-48	4.97^{bcd}	20.77^{bcd}	296.77^{cd}	9.37^{ab}	3.23^{bc}
SER_180	5.06^{abcd}	21.93^{abc}	250.5^{cdef}	7.63^{bc}	3.17^{bc}
SER-125	5.4^{abc}	17.67^{cd}	284.2^{cde}	8.97^{ab}	3.8^{a}
DUME	5.4^{abc}	22.27^{abc}	222.83^{ef}	6.37^{bc}	3.17^{bc}
Red kidney	4.73^{dc}	19.23^{cd}	414.87^{b}	8.57^{ab}	3.57^{ab}
IBADO	4.3^{d}	15^{d}	542.47^{a}	8.33^{abc}	3.53^{ab}
ETAN	5.1^{abcd}	22.77^{abc}	318.50^{c}	6.77^{bc}	2.87^{cd}
Mean	5.18	20.79	294.43	7.82	3.23
P	NS	**	***	NS	***
CV	9.87	15.18	13.72	27.64	8.14
LSD	0.86	5.34	68.39	3.66	0.45

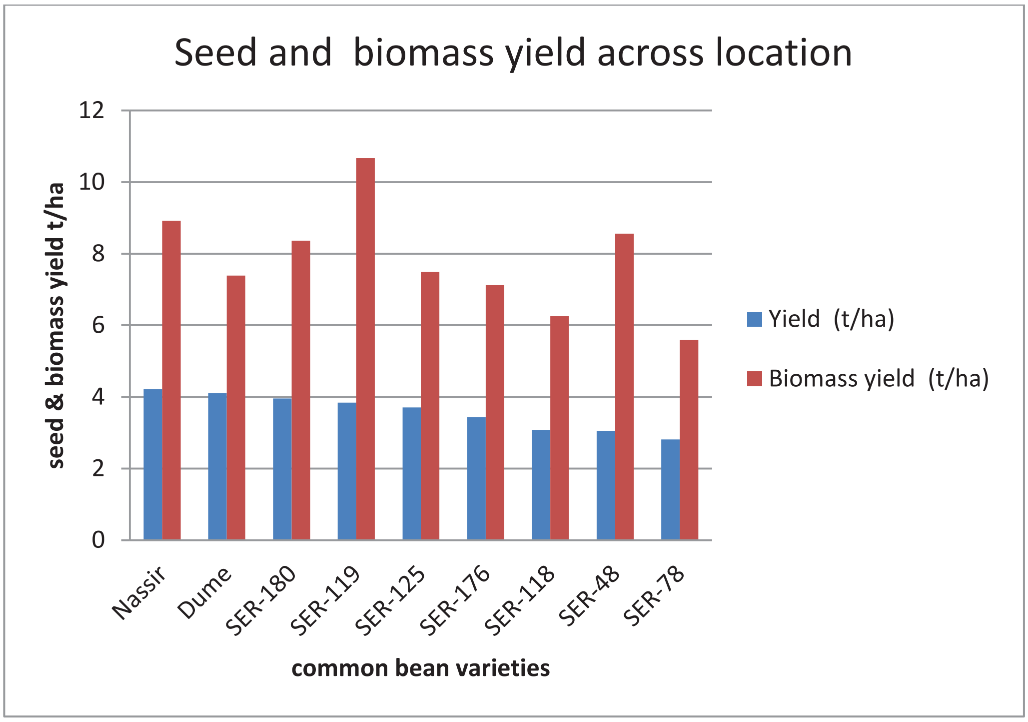

Figure 1. Seed and biomass yield (t/ha) of across location (Hawassa, Meskan and Badawacho), 2013 cropping season

Table 5. ANOVA result of seed & biomass yield of common bean varieties across location, 2013 cropping season

Varieties	Yield (tha^{-1})	Biomass yield (tha^{-1})
Nassir	4.22 $^{(a)}$	8.92 ^{ab}
Dume	4.11 $^{(ab)}$	7.39 ^{bcd}
SER-180	3.96 $^{(ab)}$	8.36 ^{bc}
SER-119	3.84 $^{(ab)}$	10.67 ^{a}
SER-125	3.71 $^{(abc)}$	7.49 ^{bcd}
SER-176	3.44 $^{(bcd)}$	7.12 ^{bcd}
SER-118	3.08 $^{(dc)}$	6.25 ^{dc}
SER-48	3.05 $^{(dc)}$	8.56 ^{abc}
SER-78	2.81 $^{(d)}$	5.59 ^{d}
Mean	3.58	7.82
LSD	0.76	2.31
P	**	**

Moreover the analysis of variance for on farms indicated that there was statistically significant difference for grain yield and biomass yield among the common bean varieties tested across location. The highest grain yield was harvested from Nassir (4.22 ton ha^{-1}) and Dume (4.11 ton ha^{-1}) while the lowest (2.81 t ha^{-1}) was recorded from SER-78 (2.6 ton ha^{-1}) and SER-48 (3.05 ton ha^{-1}). The highest biomass yield was harvested from SER-119(10.67 t ha^{-1}) and the lowest recorded from SER-78 (Table 2 & Fig 1).

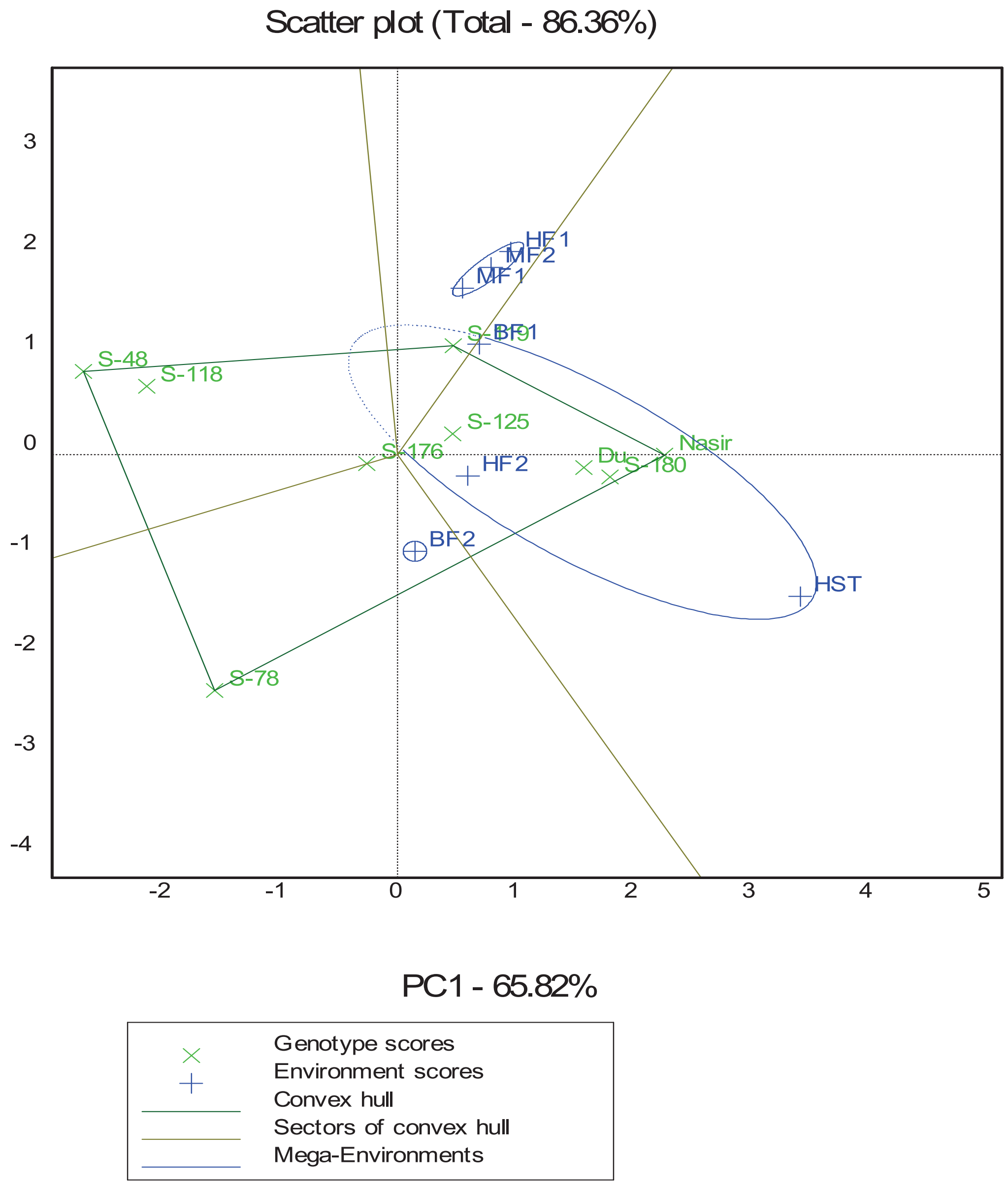

Figure 2.GGE biplot based on the grain yield performance of nine bean varieties in seven environments (locations)

Test environments are divided into three mega-environments as follows: Badawacho F2 constitute the first group, the second group consists of Hawassa on station,Hawassa Zuria F2 and Badawacho F1; while the third group comprises of Hawassa F1,Meskan FTC1 and Meskn FTC 2 (Fig 2).

GGE biplot analysis of grain yield response the principal component (PC) axis 1 explained 65.82% of total variation; while PC2 explained 20.54% and, thus these two axes accounted for 86.3% of the total variation for grain yield (Fig. 2). These results suggest that the biplot of PC1 and PC2 adequately approximated the environment centered data. The GGE biplot for grain yield of the 7 prerelease and 2 released common bean varieties evaluated at 7 locations. According to Yan (2001), in the polygon view (Fig. 2), the vertex cultivar in each sector represents the highest yielding cultivar in the location that falls within that particular sector.

Based on this information, SER-119, SER-180, Dume and Nassir were the highest yielding cultivar at Hawassa and Badawacho. The vertex cultivars, SER-48, SER-118 and SER-78 were the lowest-yielding cultivar at all locations.

Furthermore, no environments fell into the sector with lowest yielding cultivars, indicating that this cultivar was not the best in any of the environments. This also implies that it was the poorest cultivar in all of the environments.

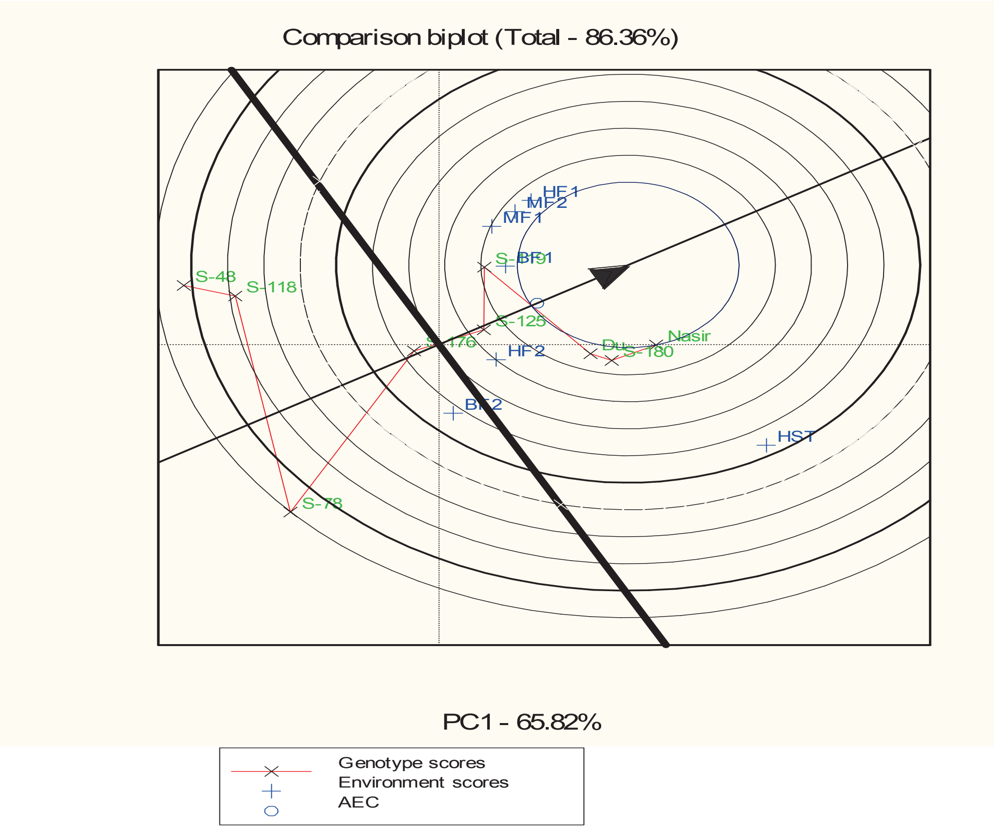

Figure 3. The biplot view showing stable and ideal common bean varieties in different location

In (Fig. 3) the center of the concentric circles is where an ideal cultivar should be. Therefore, the smaller the distance from a center, the most ideal the variety is. Thus, Dume, Nassir and SER-180 were the ideal cultivars which gave the highest yield and stable while variety SER-125 was the most stable variety but lesser yield.

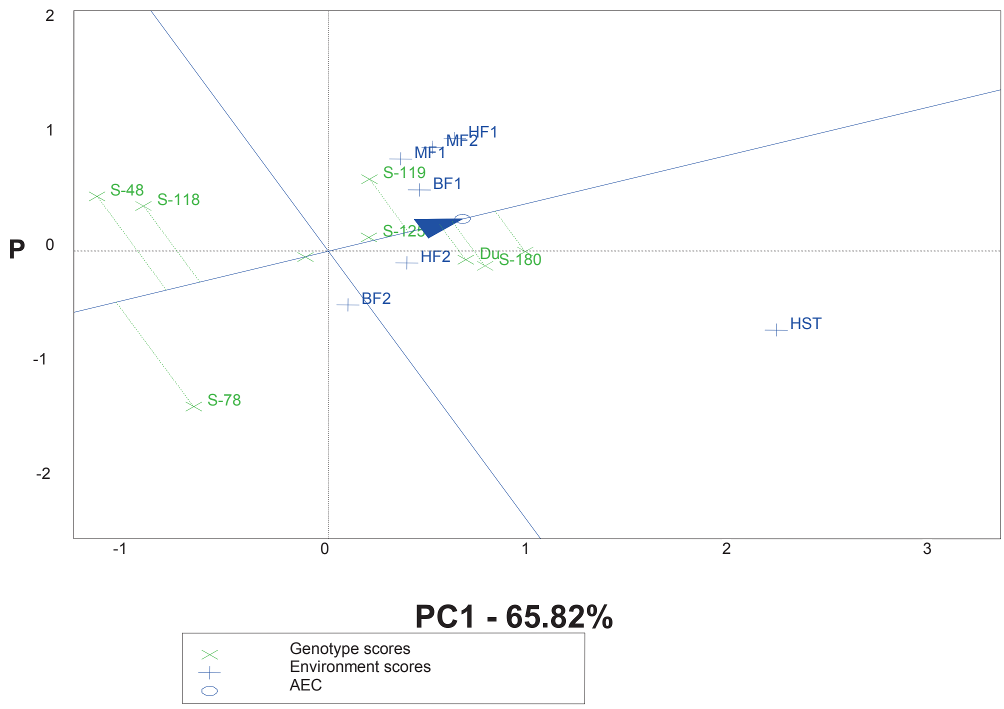

Figure 4.The 'mean vs. stability' view of the GGE biplot based on a genotype x environment yield data of 7 common bean cultivar evaluated in 7 locations.

In fig 4.Indicated that the performance of genotypes SER-48, SER-118 and SER-78 were the most variable (least stable), whereas genotypes SER-125 were highly stable while SER-119, SER-180, Dume and Nassir with high grain yield but less stable .

Conclusion

To speed up variety introduction to farmers, on-farm beans experiments were conducted in Hawassa, Badiwacho and meskan region. Nassir and Dume recorded the highest yield across the environments. However farmers ranked SER-180, SER-119, SER-125,Dume and Ibado varieties as high which were attributed to high yielding and high market demand. The GGE biplot identified SER-78,SER-48 and SER-118 as least desirable common bean varieties. While the GGE biplot analysis revealed three varieties Dume,Nassir and SER-180 were the most desirable across locations. Badawacho and Hawassaonstation were identified as best locations for genetic differentiation of genotypes, while location Meskan and Hawassazuria was the least representative.

Therefore introduction of high yielding bean varieties with the desired farmers'traits could increase beans production and could contribute to the improved food security in the region. Therefore, plant breeders should integrate farmers preference traits into bean breeding program and vital to scale-up seed production and delivery in collaboration with various seed partners.

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